Design and Development of India's First Java Based Acoustic Radar for Atmospheric Dynamics

Kartik Vats[1], Amit Kumar[2], B.K. Kushwaha[3], Basant Kumar Tyagi[4], Ruchi Chaudhary[5], Sawan Chauhan[6], Reena Rani[7], N.C. Deb[8], Suraj Kumar[9], Rakesh Gupta[10] and H.N. Dutta[11]

[1,2,3,5,6,7,9,10,11]Roorkee Engineering & Management Technology Institute, Shamli
[4]Maharaja Agrasen Institute Of Technology, Rohini, Delhi
[8]M/S Systet, 117/1/1,Sriram Dhang Road, Block-E, Salkia Howrah-711 106,India
E-mail: [1]2012cse002@remtech.in, [2]2012cse018@remtech.in, [3]eatme48@remtech.in, [4]bktyagi26@gmail.com, [5]2012cse006@remtech.in, [6]2011ece24@remtech.in, [7]eatece123@remtech.in, [8]narayandeb@gmail.com, [9]2012cse008@remtech.in, [10]eatee168@remtech.in, [11]hndutta@remtech.in

Abstract—*In India, the acoustic radar technology started in early seventies and was adopted by various groups by mid-eighties. In the meanwhile, the availability of computers and the associated software changed the entire concept of signal processing and it made the system versatile in terms of data reliability, processing, storage and data transfer for users. Our group at the Roorkee Engineering & Management Technology Institute, Shamli has developed the entire software based on Java as Java offers a simple versatile tool in implementing real world entities, enhancing data security and ease of graphical presentations.*

1. INTRODUCTION

In India, the acoustic radar technology started in early seventies [1] and was adopted by various groups by mid-nineties [2-4]. In the meanwhile, the availability of computers and the associated software changed the entire concept of signal processing and it made the system versatile in terms of data reliability, processing, storage and data transfer for users [5-8].

2. BASIC ACOUSTIC RADAR OPERATION

An acoustic radar is a simple device that captures images of the atmosphere in real-time right from surface of the earth up to a height of about a km [2,4]. Fig. 1 shows the operational block diagram of the system developed at the Roorkee Engineering & Management

In this system, a powerful acoustic pulse (12 W acoustical power) of 100 msec at a frequency of 1590 Hz is transmitted vertically up into the atmosphere and the intensity of the echo returns from thermal perturbations associated with the air, is computed to plot it as a 3D facsimile display[2,4]. The whole system is controlled by a dedicated Java supported Arduino Uno board [9-11].

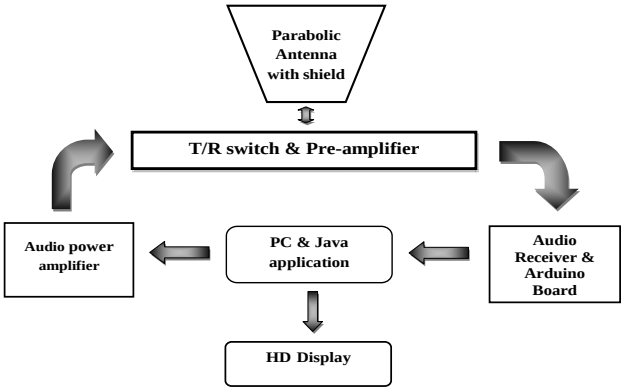

Fig. 1: Basic acoustic radar system operation flow chart Technology institute, Shamli.

3. ACTUAL SYSTEM HARDWARE

Fig. 2 shows the actual hexagonal acoustic shield, which houses a 4 feet parabolic antenna facing the sky. This antenna works in a monostatic mode (transmits as well as receives) to receive the signals to produce a facsimile display.

The acoustic shield blocks the horizontally propagating noises to enhance S/N ratio of the received signals. In REMTech acoustic radar, parabolic antenna is basically 2 feet below the shield and is surrounded by a brick wall pasted with foam. This arrangement basically enhances the effectiveness of the shield. The acoustic shield also reduces the echoing between various buildings surrounding the shield, which we have been forced to install it on the ground for a better visibility to the student and the visiting academic community. Ideally, a rooftop is preferred or it has to be an open space [2-5].

Fig. 2: Actual acoustic shield installation in progress

The electronics and the PC system are installed in a lab situated at the first floor of the building in order to minimize the cable length for both transmit and receive channels.

4. JAVA APPLICATION

Our group at the Roorkee Engineering & Management Technology Institute, Shamli has developed the entire acoustic radar system based on Java software as Java offers a simple versatile tool in implementing real world entities, enhancing data security and ease of graphical presentations [12-14]. Moreover, Java language for the development of the Acoustic RADAR offers a high level platform independent programming language [15] It is Object-Oriented, dynamic, portable, robust, multi-threaded, high- performance, interpreted, distributed and dynamic in nature [16].

3.1 Arduino board

The Arduino board is a specially designed circuit board for programming and prototyping with Atmel microcontrollers. This board plugs straight into a computer's USB port, and it is dead-simple to setup and use for various applications [17-19]. Moreover, it has an open source design and the built-in voltage regulation, which makes the Arduino board as part of the computing system itself. [17-19]

Java application of Acoustic RADAR mainly consist of 26 classes in which it includes audio package, frame package, processing package, time package and many more packages. Fig. 3 shows the basic algorithm that has been developed and implemented to control and capture the atmospheric images, leading to the study of atmospheric dynamics.

In the acoustic radar, the facsimile chart is plotted in a sequence of vertically plotted line by line. For each line, the data is captured after every 15 msec and is shown as a corresponding color pixel. Thus, each line is a plot of 267 pixels, depicting a vertical height of 680m.

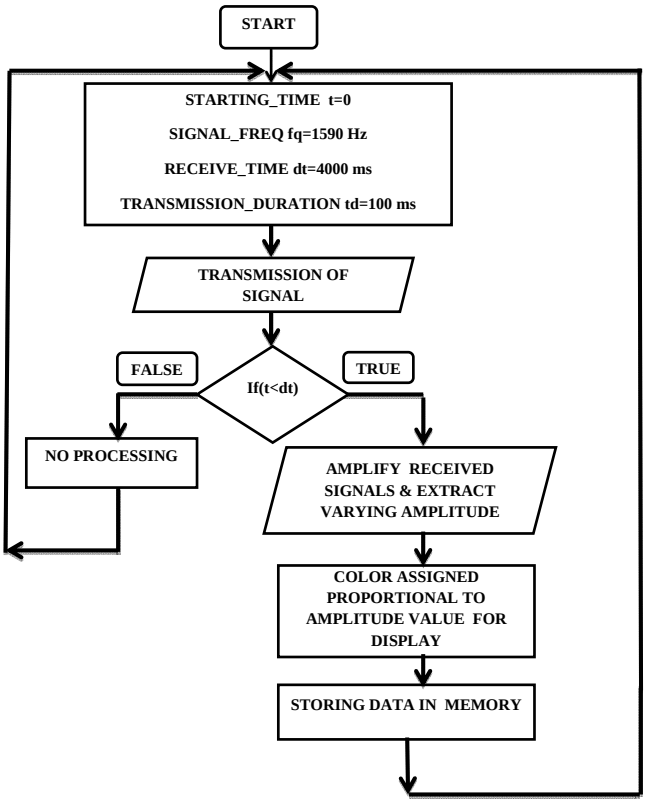

Fig. 3: flow chart of java application in acoustic radar

In reality, we take starting time t=0, signal frequency fq=1590 Hz, receive time dt=4000 msec, transmission duration td=100ms, then the system starts transmission of signal pulse. Afterwards, it checks if the starting time is less than transmission duration, it receives the received signals to extract varying amplitudes. After extracting each amplitude within 15 msec, it assigns the colors proportional to the amplitude values for display. Simultaneously, it stores the data in system memory. The process is repeated again from the starting time to get the next line. The time is taken from the real-time clock of the PC itself and automatically gets displayed at each complete hour.

The Java application works in four modules:

3.2 Selection of parameters

It selects parameters like operating frequency, pulse duration, transmission time, reception time, operational time, and port number.

3.3 Transmission

It gives the instruction to the hardware according to the parameter defined above and the signal is transmitted. The

transmission of the signal occurs after every 10 seconds while the signal is received only for a period of 4 seconds. In the period of 4 seconds, the signals are received from the surface of earth up to a height of 640m with a vertical resolution of 4.8m.

3.4 Received signals

It receives the signals and extracts the information of the distance and amplitude of the signals varying between 0-5 Volts. We divide the amplitude in different voltage ranges and assign a color code to each measured value. This varying color line is plotted according to the amplitude of the received signals on the digital display of the system with respect to time.

Fig. 3. shows the color display of a trial run over Shamli, representing vertical circulation of air during the nighttime. In nighttime, the presence of shallow surface based inversion is evident and July being the month of rainy season over northern India, steep inversions are not expected [20]. The presence of a weak elevated layer in the lower atmosphere may be due to wind shear or due to some other reasons, which we have not, studies so far.

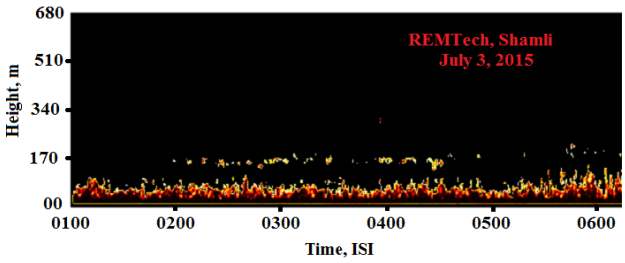

Fig. 3: A 3-D facsimile chart recorded during a trial run at REMTech, Shamli

At the moment, fixing of black stone work on the base of the shield is in progress and once it finishes, we shall fix up 32 density 100 mm thick polyurethane foam inside the shield to enhance S/N ratio. It is due to this restriction, we are making trial runs during the night only.

It may be mentioned here that the REMTech is situated ideally for establishing an acoustic radar as there are no major sources of noises (like in cosmopolitan cities), the site is surrounded by green fields from all around except the Shamli-Panipat road (State Highway-12), which passes close to the front side of the REMTech and to block the noises of the vehicles, we have placed our antenna on the backside of the laboratory block, wherein noise is the minimum.

Fig. 5. shows the site map from Google Earth and it clearly shows domination of green fields all around the acoustic radar site.

Fig. 5: Actual site map shows green fields around the acoustic radar at REMTech, Shamli

5. DISCUSSION

From the preliminary observations, it seems that the system is functioning as per the expected specifications. The Java software is performing as per its merits. However, the final outcome shall depend only after modifications in the shield are incorporated, the work is in progress.

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